FLOATING VERTICAL WINDMILL AERATION SYSTEM

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Patent Application Nos. 60/426 576 and 60/426 775, both filed November 15, 2002. The disclosure of these two applications is incorporated herein in their entirety by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to an apparatus to aerate a large body of water, such as a pond or a lake, by injecting the water with air via a wind-driven pump.

BACKGROUND OF THE INVENTION

[0003] Aerators are used to improve the habitat for animals and plants. Many such aerators or pumps are used to aerate aquariums. These are usually driven by electrical power, such as U.S. Patent No. 5 052 904.

[0004] Large scale wind-driven aerators have been developed for larger bodies of water, such as canals and ponds. One example is U.S. Patent No. 4 308 137. This patent discloses a floating aeration device having members that generate bubbles at the water surface. These bubbles are supposed to flow downward with the downward flow of water caused by an impeller. The bubbles exit from a bottom opening of a cylindrical-shaped shroud, to aerate the water immediately adjacent the shroud opening.

[0005] Other related inventions eject water upwards above the surface, causing aeration as the water re-enters the surface from above, e.g. U.S. Patent No. 3 515 375; or circulate water under the surface, e.g. U.S. Patent No. 4 764 313.

[0006] It is the object of this invention to provide an improved large-scale aerator which overcomes disadvantages associated with prior art aerators.

[0007] The invention relates to a large scale wind-driven aeration device, i.e. aerator that drives a pump to displace air through an end of a submerged aeration tube. The submerged aeration tube has a check-valve to prevent water from entering the tube, and has an outlet so the air can exit to aerate the water at any distance from the aerator, and virtually any location in a body of water.

[0008] More specifically, the aerator can float, or it can be fixed, such as being fixed to a pole. The aerator includes a rotary windmill which converts rotary motion of the windmill into a reciprocating motion of a drive lever to drive the pump. This allows for ready driving of the pump to pump air to a significant depth of over twenty feet.

[0009] Other objects and purposes of the invention, and variations thereof, will be apparent upon reading the following specification and inspecting the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Figure 1 is a pictorial view of a floating aeration device.

[0011] Figure 2 is a side view of the aeration device of Figure 1.

[0012] Figure 3 is a partial cut-away view of the rotor members of a rotary windmill and a pump housing of Figure 1.

[0013] Figure 4 is bottom view of the aeration device.

[0014] Figure 5 is a top view of the aeration device.

[0015] Figure 6A is a sectional view of the pump housing showing a magnetic drive arrangement.

[0016] Figure 6B is an enlarged two-part view comprising a side view of the pump assembly and a top view of a magnetic drive rotor.

[0017] Figure 7 is a sectional pictorial view of the pump housing.

[0018] Figure 8 is a sectional view of the pump with a drive lever in a first position.

[0019] Figure 9 is a sectional view of the pump with the drive lever in a second position.

[0020] Figure 10 is a sectional view of the floatation unit of Figure 1.

[0021] Figure 11 is a sectional view of the ballast unit of Figure 1.

[0022] Figure 12 is a side view of the aeration device and its environment of use.

[0023] Figure 13A is a partial view of a foot valve and anchor.

[0024] Figure 13B is an enlarged view of the foot valve.

[0025] Figure 14 is a pictorial view of a second embodiment with a cam drive arrangement.

[0026] Figure 15 is a pictorial view of the rotor unit of the second embodiment with a rotary cam.

[0027] Figure 16 is an enlarged view of the cam drive arrangement.

[0028] Figure 17 is a side view of the rotor unit and pump housing.

[0029] Figure 18 is a partial side view of the pump assembly for the second embodiment.

[0030] Certain terminology will be used in the following description for convenience and reference only, and will not be limiting. For example, the words "upwardly", "downwardly", "rightwardly" and "leftwardly" will refer to directions in the drawings to which reference is made. The words "inwardly" and "outwardly"

will refer to directions toward and away from, respectively, the geometric center of the arrangement and designated parts thereof. Said terminology will include the words specifically mentioned, derivatives thereof, and words of similar import.

DETAILED DESCRIPTION

[0031] Figure 1 illustrates a first embodiment of a large-scale wind-driven aeration device or aerator 30 that converts wind energy to mechanical energy to displace air into a large body of water 10 such as a lake, pond, canal or the like. The aeration device 30 comprises a rotor unit or windmill 40 having a stacked plurality of rotor members or vanes 40-1 and 40-2, a substantially hollow cylindrical pump housing 55, a cylindrical floatation unit 60, and a cylindrical ballast unit 70 which maintains the aerator 30 in an upright orientation and is physically anchored in the water body 10.

[0032] More particularly, Figure 2 shows aeration tubing 80 and anchor ropes or cables 90. The flotation unit 60 and ballast unit 70 allow the aeration device 30 to float in a body of water, and maintain its substantially vertical position by the anchor ropes 90 while air is pumped through the tubing 80 as a result of wind-driven rotation of the rotor unit 40.

[0033] Referring to Figure 3, the rotor unit 40 is fixed to a substantially vertically oriented rotor shaft 42, which has a lower end 43 non-rotatably mounted or fixed to the ballast unit 70 (Figure 11) and extends vertically within the pump housing 55 (Figure 6A). Although any member that provides wind resistance can be used as a rotor unit 40, each rotor member 40-1 and 40-2 shown in Figure 1 has curved wall plates 44, a top 46, and a bottom 48, to form pairs of concave cup-like areas

to catch the wind, and force the rotor unit 40 to rotate about a vertical axis 42A (Figure 1) of the rotor shaft 42, in a predesignated direction, e.g. counterclockwise. The rotor unit 40 rotates substantially within a horizontal plane. The inner side of each curved plate 44 defines a convex portion 45 to define sideward opening chambers 45A to catch the wind. This type of rotor is also known as a Savonius-type rotor.

[0034] More particularly, the top 46 and bottom 48 are substantially the same shape and size and may be made of metal or plastics. A first set of chambers of the upper rotor member 40-1 are fixedly disposed on opposite sides of the rotor shaft 42, and face in opposite directions. A second set of chambers of the lower rotor member 40-2 are fixed immediately below the first set by nuts and bolts 43 (Figure 3) which join the rotor members 40-1 and 40-2 together.

[0035] As shown in Figures 4 and 5, the second set of chambers of the rotor member 40-1 face directions that are substantially 90 degrees offset from the first set. When encountering a breeze, i.e. when forced by wind, each rotor member 40-1 and 40-2 will rotate the rotor shaft 42 in the predesignated direction.

[0036] If desired, a rotation-restricting locking mechanism, like that of a bicycle wheel can be employed to only allow rotation in a single direction and prevent reverse rotation.

[0037] To support the rotor unit 40, the shaft 42 extends downwardly and has an enlarged lower end 43 (Figure 11) encased within the ballast unit 70. The ballast unit 70 has a cylindrical outer casing 71 which is enclosed at a lower end by an end cap 71A and is filled with ballast material 72 which fills the casing 71. The ballast material 72 preferably is concrete which thereby provides the necessary ballast weight to hold the

aeration device 30 upright and also rigidly affixes the lower shaft end 43 in place, to essentially define a fixed vertical support or mast on which the rotor unit 40 is rotatably supported.

[0038] The upper end of the ballast unit 70 has the floatation unit 60 (Figure 10) mounted thereon. The floatation unit 60, i.e. the float, is an enclosed cylindrical disk having an interior 61 which is constructed such that the floatation unit 60 has sufficient buoyancy to support the entire weight of the aeration device 30. Preferably, the interior 61 is filled with a floatation material 62 of Styrofoam/polystyrene and has a thickness of about four inches defined by upper and lower walls or faces. The size and thickness of the floatation unit 60 can be varied to vary the buoyancy according to the overall size of the unit 30 wherein the floatation unit 60 preferably has a diameter of about three (3) feet.

[0039] The fixed shaft 42 extends centrally therethrough, wherein the ballast unit 70 and floatation unit 60 are rigidly joined together to support the remainder of the unit 30 including the pump housing 55 and rotor unit 40. As such, the shaft 42 projects vertically from the floatation unit 60 in cantilevered relation.

[0040] To rotatably support the rotor unit 40 on the shaft 42, the rotor unit 40 includes a vertically-spaced pair of sealed bearings 52 (Figure 3) housed in the body of the rotor unit 40. The rotor unit 40 is thereby vertically supported on the upper free end of the shaft 42 but also is free to rotate relative thereto. As such, an open space 53 is defined vertically between the lower face of the rotor unit 40 and the upper face of the floatation unit 60, wherein the pump housing 55 is mounted in place to enclose this space 53 and define an

interior chamber 54 in which the pump 100 (Figure 6A) is mounted.

[0041] Generally, a drive mechanism 56 connects the rotor unit 40 to the pump 100. Preferably, the pump 100 is a reciprocating, side-driven diaphragm pump wherein the drive mechanism 56 converts the rotary motion of the rotor unit 40 to a reciprocating motion to drive the pump 100.

[0042] More particularly, the pump housing 55 protects the pump 100 and other components from the elements. The pump housing 55 is constructed to allow removal of the pump 100, without removing the rotor unit 40. Within the housing 55, the rotor shaft 42 extends vertically therethrough adjacent the pump 100.

[0043] In the first embodiment of Figures 1-13, the drive mechanism 56 is a magnetic drive arrangement. The drive mechanism 56 comprises one or more arcuate-shaped rotor magnets 92 which rotate with the rotor unit 40, and a rectangular lever magnet 84 mounted at a top portion of an elongated plate-shaped pump lever 88 so as to reciprocate sidewardly in response to the rotation of the rotor magnets 92. The lever magnet 84 is in a like-pole orientation (north to north or south to south) to each arcuate-shaped rotor magnet 92.

[0044] As shown in Figures 6A, 6B and 7, the rotor magnet 92 is concentrically fixedly secured to an enlarged collar 94 or other similar bracket which if fixed to the lower rotor member 40-2 and projects downwardly therefrom so as to surround the shaft 42 adjacent the lever magnet 84. Preferably, the collar 94 is constructed of a ferrous metal. Permanent magnets are available in many materials and rare earth or neodium magnets are commercially available.

[0045] The rotor magnet 92 has a particular arc length that is less then the circumference of the collar 94.

Thus the collar 94 has at least one arc segment consisting of a rotor magnet 92, and at least one arc segment between the magnets 92. When the rotor magnet 92 is rotated in direction 95 (Figure 6B) such that it is adjacent the lever magnet 84, the polarities are aligned so that the magnets 92, 84 repel each other in direction 96, so the lever magnet 84 is forced away from rotor magnet 92. As the magnets 92 continue to rotate, the lever 88 then reciprocates linearly back toward the metal collar 92 in direction 97 by the pump 100 wherein the reciprocating motion of the lever 88 drives the pump 100.

[0046] Referring to Figures 7 and 8, the pump lever 88 extends downwardly to a lower end 103. A pivot joint 101 is disposed on a pump frame 102, just above the pump 100. Near the lower end 103 of the pump lever 88, the pivot joint 101 pivotally secures the pump lever 88 to the pump frame 96 such that the lower end 103 reciprocates effectively linearly.

[0047] Referring to Figure 8, the pump 100 is secured to a bottom plate 57 of the housing 55 by bolts 58 and is a diaphragm pump. The pump 100 has a substantially horizontally displaceable circular diaphragm 104 secured to a substantially horizontally oriented pump shaft 106. The diaphragm 104 has a perimeter 104A that slidably engages with an inside wall 105 of the pump 100 to provide for a substantially hermetic seal. The diaphragm 104, the inside wall 105, and a first end wall 107 of the pump 100 define a volume-varying pump chamber 124. The pump shaft 106 is supported by a pump bushing 109A extending through a second end wall 109 of the pump 100 to outside the pump 100, terminating in a rounded contact 108. A spring 112 is compressively disposed around the pump shaft 106, between the pump 100 and the rounded contact 108 to bias the rounded contact 108 away from the

pump 100, and toward the lower end 103 of the pump lever 88.

[0048] When the rotor magnet 92 is rotated so as to be disposed adjacent the lever magnet 84, the force of magnetic repulsion biases the upper portion of the pump lever 88 away from the rotor magnet 92, and pivots the lever 88 about the pivot joint 101 to bias the lower end 103 of the pump lever 88 toward the pump 100, as shown in Figure 9, and thereby drive the diaphragm 104 toward the pump wall 107, which compresses air therein and causes the air to displace from the pump chamber 124, into a proximal end 131 of an aeration line 130. This magnetic repulsion force is greater than the compression spring 112 force while the spring 112 generates a restoring force when the magnetic repulsion force is absent. An aeration check valve 134 is fixed within the proximal end 131 to allow air to flow out of the pump chamber 124, but prevent any fluid, i.e. water or air, to enter the pump chamber 124 from the aeration line 130. One suitable check valve 134 is a silicone duckbill check valve available from Vernay, Inc., of Ohio.

[0049] Referring to Figures 6A and 7, the aeration line 130 feeds a splitter 132 (Figure 7) to feed two air lines 133 which lines 133 extends substantially downwardly and vertically away from the pump 100, through the flotation unit 60, as shown in Figure 10. Referring to Figure 11, the aeration lines 133 further extend downwardly within the ballast unit 70 and are encased by the concrete. Near a bottom portion of the ballast unit 70 the aeration lines 133 curve to extend through the wall 71 of the ballast unit 70 in a substantially horizontal direction. The lines 133 connect to fittings 134 which fittings 134 terminate in barbed connections 138, which are disposed outside of the ballast unit 70. As shown in Figure 12, aeration tubes 80 are fixedly

secured around the barbed connections 138, and extend away from the barbed connections 138.

[0050] To anchor the aeration unit 30 in place, an eye bolt 144 is secured within a bottom portion of the ballast unit 70 on each side thereof for attachment of anchor ropes 90. At a distal end of each anchor rope 90 is an anchor 160, which rests on the bottom surface 165 of the body of water 10. The anchor devices thereby preventing tipping as well as spinning in response to rotor rotation. The anchor ropes 90 are adjacently secured to the aeration tubes 80. The anchor ropes 90 and aeration tubes 80 have about the same length to supply aeration close to the bottom 165 but still about one (1) foot or more off the bottom 165 to avoid disturbing the bottom sediment.

[0051] Referring to Figure 13, a foot valve 154 is secured within a distal portion of each aeration tube 80, which allows air to exit the aeration tube 80, to aerate the water.

[0052] As shown in Figure 14, an air-permeable diffuser hose 170 can optionally be attached to the foot valve 154 to create smaller bubbles 171 for aeration. The diffuser hose 170 has a porous wall essentially having a plurality of smaller apertures, to create a greater number of smaller bubbles, compared with use of the check valve 154 without the diffuser hose 170.

[0053] During use, as air enters the aeration line 130, it propagates to the aeration tube 80, and out of the foot valve 154. The pump 100 is readily usable for aeration depths of twenty (20) feet or more.

[0054] More particularly as to the pump 100 during use, after the rotor magnet 92 rotates so that it is not adjacent the lever magnet 84, there is no repelling magnetic force on the lever magnet 84. Here, the spring 112 biases the rounded contact 108 toward the lower

portion of the pump lever 88. Residual pressure in the pump chamber 124 can also serve to bias the rounded contact 108 towards the lower portion of the pump lever 88. As this happens, the diaphragm 104 moves in unison with the rounded contact 108, enlarging the pump chamber 124, and drawing air into the pump chamber from an air intake line 180 (Figure 8). The intake line 180 has an intake check valve 182 to allow air to enter the intake line 180, but prevents air from exiting the pump chamber 124 via the air intake line 180. The intake line 180 obtains air from an entry opening 184, as shown in Figure 6A.

[0055] In another embodiment, there is no need for the floatation unit 60, because the aeration device 30 may be free-standing or fixed to separate fixed or floating structure, such as a pole, buoy, or separate floating device.

[0056] In a further embodiment, the rotor members 40 may be configured in a conventional windmill design, in which they rotate in a substantially horizontally oriented plane.

[0057] The preferred second embodiment of the invention illustrated in Figures 14-18 is structurally and functionally, substantially the same as the first embodiment illustrated in Figures 1-13 with the following discussion being directed more particularly to the differences therebetween.

[0058] Referring to Figure 14, the second aeration unit 120 includes a disc-like cylindrical floatation unit 121 which is adapted to float on the top surface 122 of a body of water 123. The body of water 123 again is a large-scale body of water such as a pond, lake, canal or the like. The aeration unit 120 here again is adapted to supply air to a location disposed proximate the bottom 124 of the water body 123 such that the supply of air 125

travels upwardly from the bottom surface 124 to the top surface 122, aerating and intermingling with the water body along the path to the surface 122. This defines an aeration column which extends for substantially the entire depth of the water body 123 except that the air is delivered a spaced distance above the bottom surface 124 to avoid disturbing the bottom sediment.

[0059] The aeration unit 122 also includes a submerged ballast unit 126 which is filled with concrete or other suitable ballast material. The ballast unit 126 includes eyelets 127 to which anchor ropes 128 are connected and secured to the bottom 124 by heavy anchors 129. The ballast unit 126 also includes a pair of aeration lines 130 which are formed structurally the same as the aeration lines 80 and include foot valves 131 and a diffuser tubing 132.

[0060] The aeration unit 120 also includes a removable pump housing 135 and a rotor unit 136 which is defined by upper and lower rotor members 136-1 and 136-2. The rotor members 136-1 and 136-2 are formed substantially the same as the rotor members 40-1 and 40-2 wherein the two rotor members are joined together by bolts 138 as illustrated in Figure 17. The specific construction and shape of the rotor members 136-1 and 136-2 is substantially the same as that described above and thus, a detailed discussion thereof is not required.

[0061] Structurally, the rotor unit 136 is substantially the same as the rotor unit 40 in that the rotor unit 136 is rotatably mounted by a rod-like vertical mast 140 as illustrated in Figures 16-18. The mast 140 is substantially the same as the support rod 42 except that it has a two-part construction comprising a lower base section 141 and an upper support rod 142.

[0062] More particularly, the base section 141 is formed of metal square-stock having a lower end embedded

within the concrete of the ballast unit 126 to thereby project vertically above the upper surface of the floatation unit 121 so as to be enclosed within the pump housing 135. The base section 141 includes an upward-opening bore 143 in which the support rod 142 is received. The lower end of the support rod 142 is fixedly secured to the base section 141 by bolts 144. The bolts 144 pass through corresponding aligned bores in the support rod 142 and base section 141 so as to fixedly secure the support rod 142 in position and prevent rotation thereof. The upper end 146 of the support rod 142 projects vertically into the upper rotor member 136-1 and has a locking collar 147 thereon to prevent removal of the rotor unit 136 therefrom.

[0063] Further as to the rotor unit 136, the primary difference with the rotor unit 40 is the use of a cam and follower drive mechanism 150 to convert rotary motion of the rotor unit 136 into a reciprocating driving motion which drives the pump 151.

[0064] More specifically, the rotor unit 136 includes a drive tube assembly 153 which comprises a hollow tube 153 having an upper bearing 154 and a lower bearing 155 which are fixed in the opposite ends of the tube 153 and are rotatably supported on the support rod 142. The tube 153 is non-rotatably affixed to the rotor unit 136 by upstanding flanges 155 which project vertically and lie against the outer surface of the tube 153 and are clamped against the outer tube 153 by a locking collar 155A (Figure 16) such as a hose clamp. As such, the tube 153 is non-rotatable relative to the rotor unit 136 and is effectively secured in position. The lower end 156 of the tube 153 projects downwardly out of the rotor unit 136 as seen in Figures 15 and 16. The lower tube end 156 includes an eccentric cam 160 which is rigidly affixed thereto so as to rotate in unison with the rotor

unit 136. The cam 160 includes an annular drive surface 161 which faces sidewardly.

[0065] More particularly as to the pump 151, this pump is mounted on the base mast section 141 by a horizontal cross bar 165. The cross bar 165 further supports a drive lever 166 which projects vertically and reciprocates linearly sidewardly similar to the drive lever 88. However, the drive lever 166 is modified to cooperate with the cam 160 as discussed in further detail herein.

[0066] As to the mounting of the lever 166, the cross bar 165 extends sidewardly away from opposite sides of the base section 141 and includes a pair of pivot mounts 167 which have inner ends threaded sidewardly into the cross bar 165. Each pivot mount 167 also includes a pivot pin 169 which projects sidewardly and pivotally supports a pivot block 170 thereon. The pivot mounts 167 have their respective pivot pins 169 aligned in registry to define a horizontal pivot axis about which the pivot block 170 is able to pivot. The pivot block 170 includes a vertically elongate lever arm 171 which projects vertically.

[0067] The upper end of the pivot arm 170 as seen in Figure 16 includes a follower axle 172 which projects vertically and rotatably supports a cylindrical cam follower 173 thereon. The cam follower 173 is continually biased against the eccentric cam 160 and is displaced linearly sidewardly by rotation of the cam 160 in a reciprocating, linear motion. As such, rotation of the rotor unit 136 effects rotation of the cam 160 which rotates the cam follower 172 and effects sideward displacement thereof to drive the pump 151.

[0068] The lower end 174 of the lever arm includes a contact plate 175 which faces sidewardly and cooperates with the enlarged contact head 176 on the pump drive

shaft 177. The contact head 176 is biased outwardly by a spring 178 wherein reciprocating movement of the drive shaft 177 effects pumping operation of the pump 151 in the same manner as that described above relative to pump 100 wherein the cam 160 generates a driving force and the spring 178 generates a restoring force. The pump 151 includes an outlet 180 and an inlet 181 to permit operation of the pump arrangement and effect pumping of air through the outlet 180 to the aeration tubing 130. The routing of the tubing between the outlet 180 and the aeration tubing 130 is the same as that described above relative to Figures 1-13 and thus, a detailed description of such tubing is not required.

[0069] Therefore, the preferred embodiment of Figures 14-18 has a direct mechanical drive linkage between the rotating rotor unit 136 and the reciprocating lever arm 166 to thereby drive the pump 151. The cam 160 and follower 173 thereby convert the rotary motion of the rotor unit 136 into the reciprocating driving motion of the drive shaft 177. The ratio of the length of the lever arm 171 extending vertically above the pivot pins 169 as compared to the lower portion of the arm extending below the pivot pins 169 provides mechanical advantage such that relatively low wind forces are only required to drive the rotor unit 136. As such, the aeration unit 120 is able to readily operate even in low wind conditions. Further, the pump 151 is able to pump the air to a significant depth of at least twenty feet which allows usage of the aeration unit 120 in large bodies of water. Also by varying the length of the anchor ropes 128 and the tubing 130, the aeration unit 120 can be used even in relatively shallow bodies of water so long as the floatation unit 121 is able to float. Further, as referenced above, the aeration unit 120 may also be modified for fixing to a fixed structure such as a dock

or a mounting pole or even to a pre-existing floating structure such as a buoy.

[0070] Although particular preferred embodiments of the invention have been disclosed in detail for illustrative purposes, it will be recognized that variations or modifications of the disclosed apparatus, including the rearrangement of parts, lie within the scope of the present invention.